UDC 332.83; 711.4

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Cost modeling of integrated urban development

The article addresses land and property sustainability management objectives to implement the idea of sustainable development of urban areas. It is noteworthy that a land plot serves as the urban development framework that goes through the following stages in the process of transformation: 1) idea and conception of improvements; 2) design of improvements; 3) construction; 4) operation; 5) facility liquidation. The authors emphasize that the effective reproduction of housing requires tools of spatial economic modelling of projects for the integrated development of areas. Principal components of the basic element of the urban fabric were analyzed to develop the cost model of the integrated development of urban areas. In addition to elements of basic infrastructure (social, engineering, public and business, housing, transport infrastructure, as well as infrastructure for economic activities), the model has improvement factors for each unit of infrastructure, which demonstrate the need to improve the quality of basic elements against the regulatory benchmark to increase the total capitalization of urban assets. Sources of funding the integrated development of urban areas are presented as two units of infrastructure divided into funds of households, developers (builders), construction co-investors; funds of corporate suppliers of resources; budget resources; loan resources. To ensure the integrated development of areas, not involved in urban planning activities, cost models were developed for the integrated development of areas occupied by industrial enterprises, dilapidated individual houses, country houses and mom-commercial partnerships of gardeners, as well as disturbed urban areas (shallow and flooded areas, ravines, steep slopes). The ability to take into account features of each area will facilitate the sustainable development of cities and the whole country.

Keywords: *sustainable development, urban infrastructure, cost model, cost efficiency, sources of funding*

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The implementation of the idea of sustainable development of residential housing through the attainment of social, economic, and environmental goals accompanies the process of transition from resource consumption to integrated reproduction of resources [1]. The sufficient reproduction of adequate quality housing that meets the needs of the population, coupled with the maintenance of proper performance characteristics of residential housing contribute to its safe and effective use in the present and future. In this case, regular and extended reproduction of housing and facilities of utility, social, public, business and transport infrastructure is a factor of sustainable development of urban areas [2]. The general model used for the reproduction of housing and infrastructure is presented in Fig. 1. Effective housing reproduction needs spatial economic modelling tools applicable to the integrated spatial development projects. The spatial economic modelling of such projects is an analytical tool used to assess the investment attractiveness of the area that can accommodate a project, taking into account urban planning and economic constraints, financial feasibility of the architectural and urban planning concept (master plan) of integrated development[1].

The basic approach to IDA project selection of an is the choice of such an area to be transformed, that will ensure the implementation of an economically viable project amid existing urban planning constraints (density and functionality of development), and, hence, it will raise private equity and minimize budget expenditures, on the one hand, and maximize the benefit to be obtained by the property owners, on the other hand by boosting the value (capitalization) of the area as a result of the implementation of the IDA project.

Each major element of the urban fabric has the following basic elements: social infrastructure S_i, engineering infrastructure En_i, public and business infrastructure P_i, economic activity infrastructure Ec_i, housing infrastructure H_i, transportation infrastructure T_i. As a result, the total cost C_i of integrated development of urban areas can be presented as (1):

$$C_i = \sum_{i=1}^{n} S_i k_S + \sum_{i=1}^{n} En_i k_{En} + \sum_{i=1}^{n} P_i k_P + \\ + \sum_{i=1}^{n} Ec_i k_{Ec} + \sum_{i=1}^{n} H_i k_H + \sum_{i=1}^{n} T_i k_T, \quad (1)$$

$$k_S,\ k_{En},\ k_P,\ k_{Ec},\ k_H,\ k_T \geq 1.0,$$

where k_s, k_{En}, k_P, k_{Ec}, k_H, k_T are improvement factors for social, engineering, public and business infrastructure, economic activity infrastructure, housing and transport infrastructure. They demonstrate the need to improve the quality of basic elements of infrastructure as parts of the urban fabric against the established standards to increase the total capitalization of urban assets. The value of the coefficient set for each element of infrastructure is determined by the location of the developed area, depending on its proximity to the city centre (the largest value). These values explain what components need to be improved to exceed the standard values, the extent of an increase and

1 Methodological recommendations on spatial and economic modeling of projects of integrated development of residential areas. Ministry of Construction of Russia. URL: https://view.officeapps.live.com/op/view.aspx?src=http://www.minstroyrf.ru/upload/iblock/4ae/Metodicheskie_rekomendatsii_po_prostr._ekon._modelirovaniyu_proektov_KRT_zhiloy_zastroyki.docx (rus.).

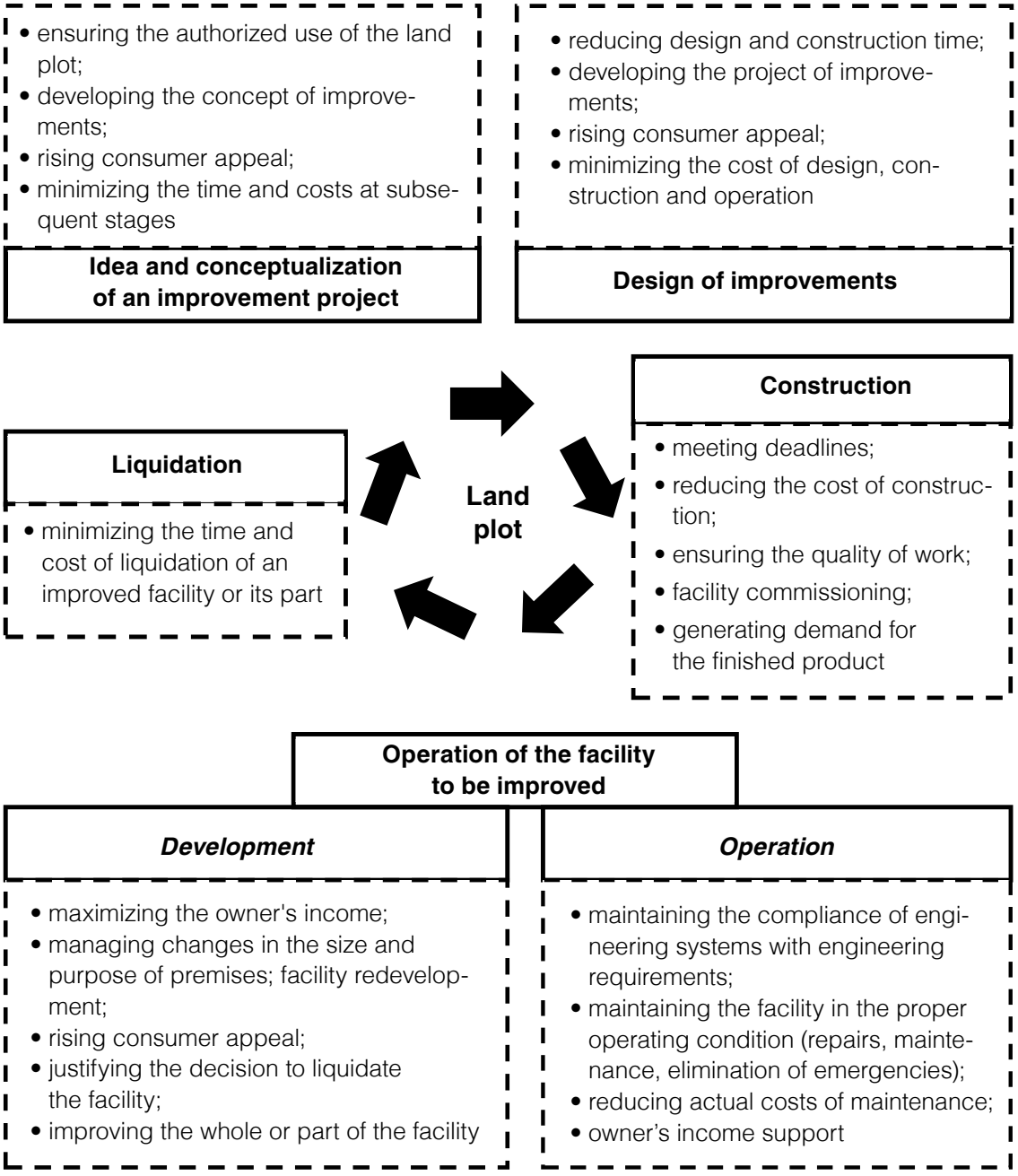

Fig. 1. Objectives of managing the sustainable development of land and property (a real estate facility)

the location of these elements to maximize the residential and commercial property margin.

Sources of funding, designated for the integrated development of urban areas, are outlined in Fig. 2 [3, 4].

If we address the reproduction of housing, public and business infrastructure, as well as infrastructure for economic activities, the major source is the funds of households and participants in shared construction, or savings, loans and state support funds. Few builders and developers contribute their cash into construction projects, while the majority uses different types of borrowed resources.

Engineering infrastructure is reproduced at the expense of consumers of housing and utility services: residents compensate for the expenses incurred in the course of reconstruction, modernization or construction of new engineering facilities in accordance with investment commitments about the implementation of municipal investment programmes undertaken by owners and at the expense of legal entities and natural persons acting as investors making investments into construction and development of the housing and utilities infrastructure. In addition, a large share of social and transport infrastructure facilities is paid for from the federal budget as the state support (the so-called infrastructure menu), regional budgets that make investments into target programmes for the development of local settlements. Some facilities of social, engineering and transport infrastructure are funded from extra-budgetary sources, including public-private partnership (PPP), the majority of which are concession agreements [5].

The analysis of spatial structure of large Russian cities has proven that industrial areas occupy 14–17 % (8–19 thousand hectares) of

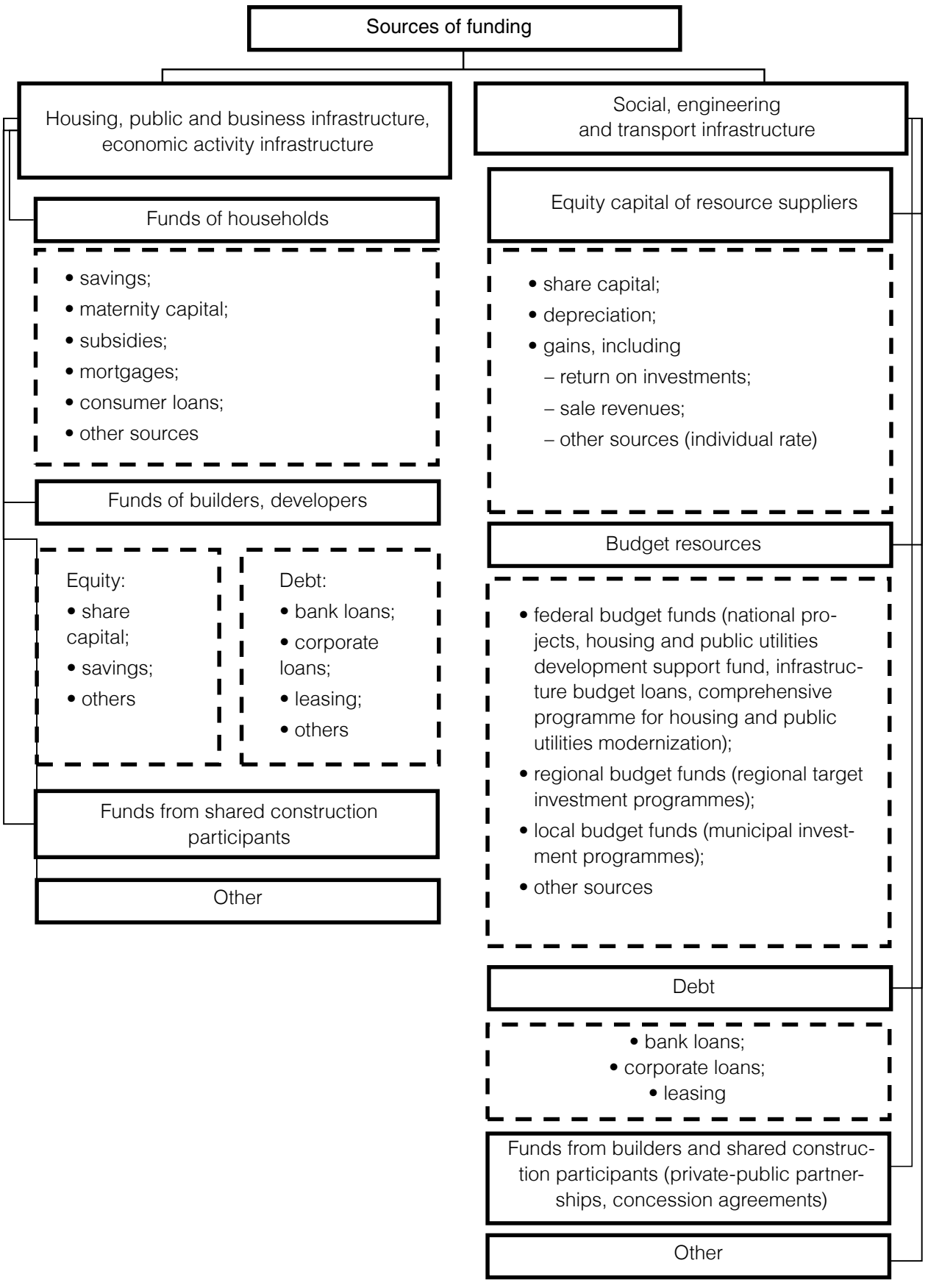

Fig. 2. Sources of funding for the integrated development of urban areas

the total city area, while dilapidated single-family houses and country house communities occupy 10–14 % (7–10 thousand hectares), and disturbed lands (waterlogged and shallow water areas, ravines, steep slopes and other areas not involved in urban planning activities) is on average 6 % of the total urban areas [6, 7].

The research has cost models for the integrated development of largest areas ignored by the urban planning projects in large cities [8, 9].

1. Cost model for the development of areas occupied by industrial enterprises:

$$C_{con} = C_{n.c} + C_{buy} + C_{dis} + C_{rec} + C_{other}. \quad (2)$$

2. Cost model for the development of areas occupied by dilapidated single-family houses:

$$C_{con} = C_{n.c} + C_{com} + C_{ev} + C_{dis} + C_{other}. \quad (3)$$

3. Cost model for the development of areas occupied by country houses:

$$C_{con} = C_{n.c} + C_{com} + C_{eva} + C_{dis} + C_{eng} + C_{other}. \quad (4)$$

4. Cost model for the development of disturbed urban areas:

it is proposed to estimate the cost of construction in shallow water and waterlogged areas according to the formula:

$$C_{con} = (C_{n.c} + C_{dr}V)k. \quad (5)$$

It is proposed to estimate the cost of construction, taking into account an increase in cost due to the development of ravine areas:

$$C_{con} = (C_{n.c} + C_e + C_{dr})k. \quad (6)$$

The cost of construction can be estimated using the following formula that takes into account an increase in price due to the development of steep slopes:

$$C_{con} = (C_{n.c} + C_e + C_{sp})k. \quad (7)$$

Formulas (2)–(7) use the following designations: C_{con} is the total construction cost; $C_{n.c}$ is the construction cost under normal conditions; C_{buy} is the cost of acquisition of an industrial enterprise from the owner; C_{dis} is the cost of demolition and dismantling of existing buildings; C_{rec} is the cost of reclamation of a land plot (in case of a hazardous production facility that was in operation there); C_{other} is other contingencies (identification and preservation of cultural heritage; archaeological research; additional court charges); C_{com} is the cost of compensation due and payable to owners of single-family houses, garden property; C_{ev} is the cost of evaluation of the property within the boundaries of areas selected for comprehensive development; C_{eng} is the cost of construction or modernization of engineering infrastructure within the area; C_{dr} is the average cost of drainage arrangement (per 1 m^3); V is the amount of drainage arrangement work, in m^3; k = 1–1.45 is the coefficient that takes into account higher construction costs due to severe working environments and longer hours of construction machine operation; C_e is the average cost of earthwork; C_{dra} is the average cost of drainage and extra efforts aimed at groundwater management; C_{sp} is the average cost of slope strengthening work.

The cost modeling of the integrated development of various urban areas, taking into account the characteristics of each area will stimulate the sustainable development not only in urban areas, but also in the country as a whole, since more than 75 % of Russia's GDP is generated by the cities. Synchronization between current and future state programmes at all government levels, private investments, and special taxation regimes will level the “shocking” effects on the country's budget in the course of development of urban areas.

REFERENCES

1. Vasilyeva O.T. Reproduction processes as basis for strategic development of housing sphere. Intelligence. Innovation. Investment. 2013; 3:10-14. URL: https://elibrary.ru/item.asp?id=20371139 (rus.).
2. Alekseev S.A., Viktorov M.Yu., Grabovy P.G., Zaitseva L.I., Kazansky N.V., Kaminsky M.A. et al. Spatial restructuring. New meanings and rules of investment and construction activity : monograph. N.Y. Yaskova (ed.). Moscow, Publishing House Delo, 2019; 454. (rus.).
3. Efimov V.S., Sarchenko V.I., Lapteva A.V., Shishatsky N.G., Efimov A.V., Bryukhanova E.A. City — idea and practice. Krasnoyarsk, Siberian Federal University, 2019; 522. (rus.).
4. Grishina N.P. Financing funds of project for complex territory development. Bulletin of the Saratov State Socio-Economic University. 2009; 5(29):72-79. URL: https://elibrary.ru/item.asp?id=13077367 (rus.).
5. Sarchenko V.I. Approaches to urban area investment potential evaluation. Bulletin of Irkutsk State Technical University. 2015; 8:202-213. (rus.).
6. Yaskova N.Yu., Sarchenko V.I., Hirevich S.A. Comprehensive approach to creating a quality urban environment. Real Estate: Economics, Management. 2020; 2:12-21. DOI: 10.22227/2073-8412.2020.2.12-21 URL: https://elibrary.ru/item.asp?id=44822019 (rus.).
7. Astafyev S.A., Sarchenko V.I., Yakubovsky A.V., Hirevich S.A., Pukhova V.V. Developing evaluation mechanism of socioeconomic efficiency of urban planning projects by local government bodies. Baikal Research Journal. 2020; 11(2):6. DOI: 10.17150/2411-6262.2020.11(2).6 (rus.).
8. Petrova E.A. Model of project cost management for integrated cluster housing. Bulletin of the Leningrad State University named after A.S. Pushkin. 2014; 6(3):53-60. URL: https://elibrary.ru/item.asp?id=23011876 (rus.).
9. Sarchenko V.I. Organizational-economic model of development of urban areas with hidden potential. Economics of Construction. 2015; 2(32):36-41. URL: https://elibrary.ru/item.asp?id=23218282 (rus.).

Стоимостное моделирование комплексного развития городских территорий

Для воплощения идеи устойчивого развития городских территорий в статье рассмотрены задачи управления устойчивым развитием всего земельно-имущественного комплекса. Отмечено, что основой развития в городе является земельный участок, который в процессе преобразования проходит следующие стадии: 1) идея и формирование замысла проекта улучшений; 2) проектирование улучшений; 3) строительство; 4) эксплуатация; 5) ликвидация объекта. Авторами отмечается, что для эффективного воспроизводства жилого фонда необходимо использовать инструменты пространственно-экономического моделирования проектов комплексного развития территорий. По результатам анализа базовых составляющих основного элемента планировочной структуры города была сформирована стоимостная модель комплексной застройки городских территорий, которая включает в себя помимо основных инфраструктурных элементов (социальная, инженерная, общественно-деловая, жилищная, транспортная инфраструктура, а также инфраструктура экономической

деятельности) коэффициенты улучшения для каждого инфраструктурного блока, которые отражают необходимость повышения качества базовых элементов по сравнению с нормативным для увеличения совокупной капитализации городских активов. Отдельно представлены источники финансирования комплексной застройки городских территорий по двум инфраструктурным блокам, которые подразделяются на: средства домохозяйств, застройщиков (девелоперов), участников долевого строительства; средства ресурсоснабжающих организаций; бюджетные ресурсы; заемные ресурсы. Для комплексного развития площадей, не вовлеченных в градостроительную деятельность, предложены стоимостные модели комплексного развития территорий, занятых промышленными предприятиями, ветхими индивидуальными жилыми домами, дачными и садовыми товариществами, а также нарушенных городских территорий (мелководные и подтопляемые, овраги, крутые склоны). Учет особенностей каждой территории послужит стимулом для устойчивого развития как городов, так и страны в целом.

Ключевые слова: *устойчивое развитие, инфраструктура города, стоимостная модель, экономическая эффективность, источники финансирования*

СПИСОК ИСТОЧНИКОВ

1. Васильева О.Т. Воспроизводственные процессы как основа стратегического развития жилищной сферы // Интеллект. Инновации. Инвестиции. 2013. № 3. С. 10–14. URL: https://elibrary.ru/item.asp?id=20371139

2. Алексеев С.А., Викторов М.Ю., Грабовый П.Г., Зайцева Л.И., Казанский Н.В., Каминский М.А. и др. Пространственная реструктуризация. Новые смыслы и правила инвестиционно-строительной деятельности : монография / под общ. ред. Н.Ю. Яськовой. М. : Изд-во Дело, 2019. 454 с.

3. Ефимов В.С., Сарченко В.И., Лаптева А.В., Шишацкий Н.Г., Ефимов А.В., Брюханова Е.А. Город — идея и практика. Красноярск : Сиб. федер. ун-т, 2019. 522 с.

4. Гришина Н.П. Источники финансирования комплексных инвестиционных строительных проектов // Вестник Саратовского государственного социально-экономического университета. 2009. № 5 (29). С. 72–79. URL: https://elibrary.ru/item.asp?id=13077367

5. Сарченко В.И. Подходы к оценке инвестиционного потенциала городских территорий // Вестник Иркутского государственного технического университета. 2015. № 8. С. 202–213.

6. Яськова Н.Ю., Сарченко В.И., Хиревич С.А. Комплексный подход к формированию качественной городской среды // Недвижимость: экономика, управление. 2020. № 2. С. 12–21. DOI: 10.22227/2073-8412.2020.2.12-21 URL: https://elibrary.ru/item.asp?id=44822019

7. Астафьев С.А., Сарченко В.И., Якубовский А.В., Хиревич С.А., Пухова В.В. Формирование механизма оценки социально-экономической эффективности градостроительных проектов органами местного самоуправления // Baikal Research Journal. 2020. Т. 11. № 2. С. 6. DOI: 10.17150/2411-6262.2020.11(2).6

8. Петрова Е.А. Модель управления стоимостью проекта комплексной жилой застройки // Вестник Ленинградского государственного университета им. А.С. Пушкина. 2014. Т. 6. № 3. С. 53–60.

9. Сарченко В.И. Организационно-экономическая модель развития городских территорий со скрытым потенциалом // Экономика строительства. 2015. № 2 (32). С. 36–41. URL: https://elibrary.ru/item.asp?id=23218282

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For citation: Sarchenko V.I., Khirevich S.A. Cost modeling of integrated urban development. *Real estate: economics, management*. 2022; 4:50-54.

Для цитирования: *Сарченко В.И., Хиревич С.А*. Cost modeling of integrated urban development // Недвижимость: экономика, управление. 2022. № 4. С. 50–54.